+6

OIPE JC54
MAR 2 5 2002
PATENT & TRADEMARK OFFICE

S/N 10/005210

PATENT

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

Applicant:	HUI et al.	Examiner:	Unknown
Serial No.:	10/005210	Group Art Unit:	2836
Filed:	12/04/2001	Docket No.:	12364.27USU1
Title:	MAXIMUM POWER TRACKING TECHNIQUE FOR SOLAR PANELS		

CERTIFICATE UNDER 37 CFR 1.10
"Express Mail" mailing label number: EV037638825US
Date of Deposit: 25 March 2002
I hereby certify that this paper or fee is being deposited with the United States Postal Service 'Express Mail Post Office To Addressee' service under 37 CFR 1.10 on the date indicated above and is addressed to the Assistant Commissioner Trademarks, BOX: NEW APP, 2900 Crystal Drive, Arlington, VA 22202-3513.

By: [signature]
Name: Chris Stordahl

PETITION UNDER 37 C.F.R. §1.182

BOX MISSING PARTS
Assistant Commissioner for Patents
Washington, D.C. 20231

Dear Sir:

In response to the Notice to File Missing Parts mailed on 25 January 2002, Applicants hereby provide a marked-up copy of drawing sheets 3 and 4 showing the correct numbering of Figure 8 and Figure 9 that were originally filed with the application on December 4, 2001. The description of the Figures on page 5 in the specification is inaccurate. In fact, Figure 8 has only one illustration and Figure 9 has three illustrations (a-c). As further evidence, Applicants also provide page 13 of the specification that refers to Figure 8 on line 23, and page 14 that refers to the three different values illustrated in Figures 9(a)-9(c). Applicants respectfully submit no items were omitted in the filing of this application. No new matter has been added. Formal correction to the specification and drawing sheets will be made with the Applicants' response to the first Office Action.

03/29/2002 BABRAHA1 00000065 10005210
01 FC:122 130.00 OP

RECEIVED
APR 1 5 2002
OFFICE OF PETITIONS

Applicants respectfully request that the $130.00 petition fee be refunded at this time as sufficient evidence has been proffered to indicate that no items of information were omitted in the filing of this application.

If a telephone conference would be helpful in resolving any issues concerning this communication, please contact Applicants' primary attorney-of record, Michael D. Schumann (Reg. No. 30,422) at (612) 336.4638.

Respectfully submitted,

MERCHANT & GOULD P.C.
P.O. Box 2903
Minneapolis, Minnesota 55402-0903
(612) 332-5300

Dated: 25 March 2002

By ______________________
Michael D. Schumann
Reg. No. 30,422

MDS/kjr

decrease the duty cycle. The above regulatory actions cause the feedback network to adjust the duty cycle, in order to make $\Phi = 1$ or $r_i = r_g$.

The embodiment of Fig.4 has been experimentally checked using the set-up shown in Fig.5 and using a solar panel Siemens SM-10 with a rated output power of 10W. The component values of the SEPIC converter are as shown in Fig. 4. The output resistance R equals 10Ω. The switching frequency is set at 80kHz and the injected sinusoidal perturbation frequency is 500Hz. The radiation level illuminated on the solar panel is adjusted by controlling the power of a 900W halogen lamp using a light dimmer. The bypass switch is used to give the maximum brightness from the lamp for studying the transient response. The surface temperature of the panel is maintained at about 40°C. The measured v_g - i_g characteristics and the output power versus the terminal resistance of the solar panel at different power P_{lamp} to the lamp are shown in Fig. 6(a) and Fig. 6(b), respectively. Under a given P_{lamp}, it can be seen that the panel output power will be at its maximum under a specific value of the terminal resistance. When P_{lamp} equals 900W (i.e., full power), the required terminal resistance is 14Ω, in order to extract maximum power from the solar panel. Thus, by applying (24) and (26), $D_{\min}$ and $D_{\max}$ equal 0.274 and 0.675, respectively. Based on (9), the variation of the input resistance is between 14Ω and 70Ω, which are well within the required tracking range of the input resistance shown in Fig. 6(b).

Detailed experimental waveforms of the gate signal, the switch voltage stress, the converter input terminal voltage, and the input inductor current in one switching cycle at the maximum lamp power are shown in Fig. 7. Macroscopic views of the switch voltage stress, input voltage, and input current are shown in Fig. 8. It can be seen that a low-

frequency variation of 500Hz is superimposed on all waveforms. They are all in close agreement with the theoretical ones. In addition, the input current is continuous. Thus, the MPP tracking method and apparatus of this embodiment of the present invention is better than the one using classical buck-type converter which takes pulsating input current. Moreover, it is unnecessary to interrupt the system, in order to test the open-circuit terminal voltage of the solar panel.

Fig. 9 shows the ac-component of the converter input terminal voltage with $\Re$ equal to 0.02, 0.05, and 0.1, respectively. As $\Re$ increases, the ac-component will be distorted because the second-order harmonics become dominant in (15).

In order to observe the feedback action of the proposed approach under a large-signal variation in the radiation level, P_{lamp} is changed from 500W to 900W. The transient waveform of the feedback signal is shown in Fig. 10. The settling time is about 0.4 seconds. Based on the results in Fig. 6(b), a comparison of the maximum attainable output power and the measured output power with the proposed control scheme under different P_{lamp} is shown in Fig. 11. It can be seen that the proposed control technique can track the output power of the panel with an error of less than 0.2W. A major reason for the discrepancy is due to the variation of β with respect to the duty cycle shown in (23), which will directly affect the tracking accuracy.

The methodology of this first embodiment of the invention is based on connecting a pulsewidth-modulated (PWM) DC/DC converter between a solar panel and a load or battery bus. In this embodiment a SEPIC converter operates in discontinuous capacitor voltage mode whilst its input current is continuous. By modulating a small-signal sinusoidal perturbation into the duty cycle of the main switch and comparing the